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GUIDELINES FOR DESIGN AND CONSTRUCTION OF MOULD AND CORE DRYING OVENS FOR FOUNDRIES

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MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG
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Indian Standard

GUIDELINES FOR DESIGN AND CONSTRUCTION OF MOULD AND CORE DRYING OVENS FOR FOUNDRIES

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Indian Standard

GUIDELINES FOR DESIGN AND CONSTRUCTION OF MOULD AND CORE DRYING OVENS FOR FOUNDRIES

0. FOREWORD

0.1 This Indian Standard was adopted by the Indian Standards Institution on 14 June 1982, after the draft finalized by the Industrial Fuel-Fired Furnace Sectional Committee had been approved by the Structural and Metals Division Council.

0.2 In a foundry, an oven is used for drying and baking moulds and cores. Generally an oven is tailor-made for a specific end-use. However, in this standard an effort is made to stipulate the general guidelines affecting the various parameters connected with design, location and construction of an oven.

0.3 This standard is set forth under classification of such units operating at approximately atmospheric pressure and a maximum temperature of 500°C.

0.4 For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the result of a test or analysis, shall be rounded off in accordance with IS : 2-1960*. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

1. SCOPE

1.1 This standard gives guidelines for design and construction of mould and core drying ovens for use in foundries, with any of the following fuels:

- a) fuel oil,
- b) liquefied petroleum gases (LPG),

*Rules for rounding off numerical values (*revised*).

- c) LPG — air mixture,
- d) natural gas, and
- e) coke oven or producer gas.

2. TYPES OF OVENS

2.1 Ovens can be classified broadly in two categories:

- a) batch type, and
- b) continuous type.

2.1.1 Batch type oven includes all ovens in which the work charge is introduced all at one time or intermittently. The evaporation of moisture within the oven is not at a constant rate.

2.2 A detailed classification of ovens is shown in Fig. 1.

3. OVEN HEATERS

3.1 The oven heaters may be classified in two categories as follows:

- a) *Indirect System* — In this system, the burner along with the combustion chamber is effectively separated from the oven chamber and is so arranged that the products of combustion from the burner are mixed with the recirculated hot gases from the oven chamber in a mixing duct and fed back to the oven chamber in a closed circuit. Eighty percent of the spent gases from oven are recirculated in the annulus of hot air generator and mixed with combustion product. Twenty percent of the spent gases are exhausted. Fresh air is either blown or induced (see Fig. 2, schemes I and II).
- b) *Direct System* — In this system, the combustion chamber is wholly or partly inside the oven chamber. The burner system is separated from the oven chamber and is on the oven chamber casing. Hot gases from the oven chamber are recirculated inside the oven chamber (see Fig. 2, Scheme III). Fresh air is blown by a recirculation fan.

3.1.1 The characteristics of different categories of oven heating systems are given below:

<i>Characteristic</i>	<i>Indirect System (Scheme I)</i>	<i>Indirect System (Scheme II)</i>	<i>Direct System (Scheme III)</i>
Fresh air	Induced	Blown by a blower	Blown by recirculation fan

Suction fan

— Inlet	From hot air	From oven outlet	From oven outlet
— Outlet	To oven inlet	To hot air generator	To combustion chamber
Exhaust fan	A separate fan is required	No separate fan required	No separate fan required

4. LOCATION

4.1 Ovens shall be so located and erected that the structural members of the building are not adversely affected by the maximum anticipated temperatures.

4.2 Ovens should be well separated from valuable stock, important power equipment, machinery and sprinkler risers, thereby securing a minimum interruption to production and protection in case of accidents to the oven.

4.3 Ovens should be safely located and protected from exposure to dip tanks, spray booths, storage and mixing room for flammable liquids or exposure from or to the diffusion of flammable air vapour mixtures.

4.4 Ovens shall be readily accessible with adequate space above to permit installation of automatic sprinklers, proper use of hose streams, the proper functioning of explosion vents, inspection and maintenance.

4.5 Combustible roofs and floors of ovens shall be ventilated to keep temperature below 71°C or shall be well insulated.

4.6 The external temperature of the floor near the oven shall not be more than 121°C when supporting floor is of concrete, steel channels or tiles. Adequate insulation therefore should be further provided, equivalent to the insulation provided for the oven walls and roof, bearing in mind the need of protection against mechanical damage or abrasion.

4.7 When oven ducts or stacks pass through combustible walls, floors or roofs, adequate insulation and clearance shall be provided to prevent surface temperature of combustible materials exceeding 71°C.

5. MATERIALS OF CONSTRUCTION

5.1 The construction of all parts, whether specifically covered by this standard or not, shall be in accordance with reasonable concepts of safety, substantiality and durability. The equipment and its construction shall provide at least a performance level equivalent to that covered herein.

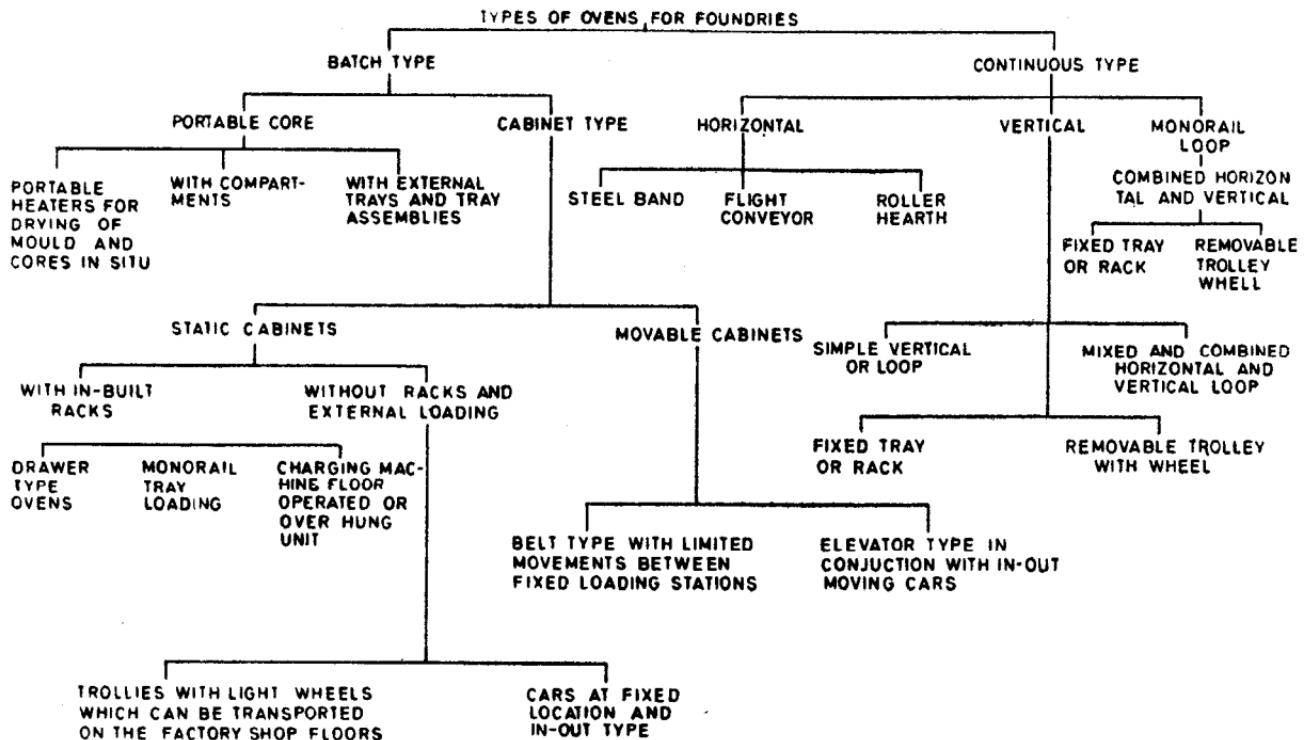


FIG. 1 CLASSIFICATION OF OVENS

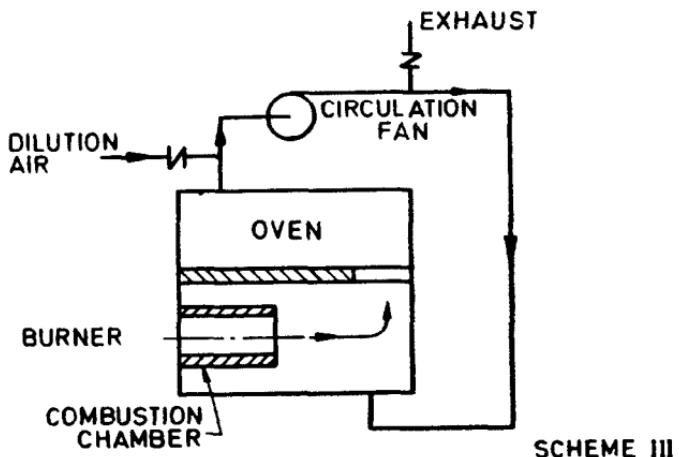
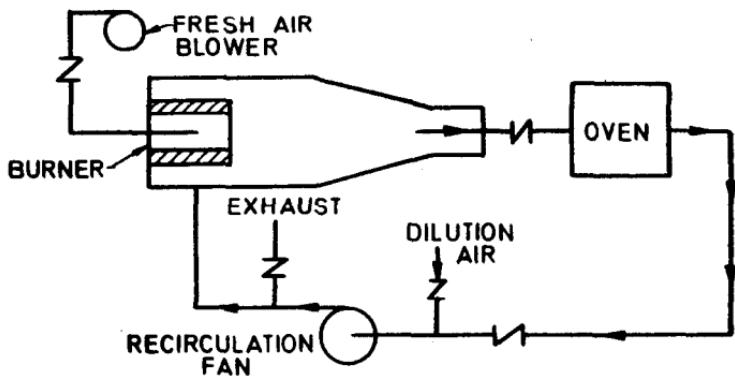
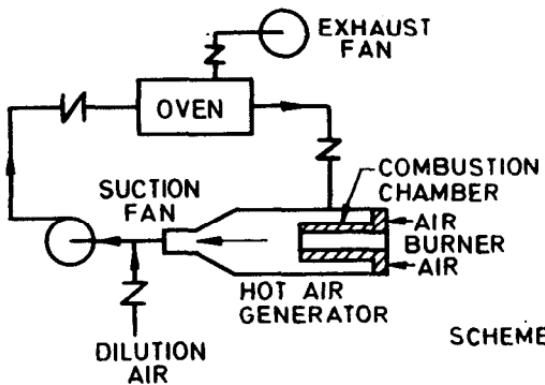


FIG. 2 CLASSIFICATION OF HOT AIR GENERATOR SYSTEMS

5.2 The oven shall be constructed of panels having hot rolled sheet steel and shall be not less than 1.6 mm thick with 125 mm mineral insulation, uniformly packed to provide even protection and to prevent shifting. The panels shall have adequate expansion joints to withstand bending stresses and to prevent bulging when fabricated with the structural of the oven.

5.3 Oven structural supports and conveyors shall be designed with adequate factors of safety, at the maximum operating temperatures against the strains imposed by expansion.

5.4 Adequate facilities for access shall be provided to permit proper inspection and maintenance, such as ladders, steps and guard rails, etc.

5.5 Auxiliary equipment, such as conveyors, racks, trays, shelves and hangers shall be noncombustible and designed to facilitate cleaning.

5.6 Burners of all types shall be substantially constructed and guarded to resist mechanical damage.

5.7 Combustion safeguard mounts, and control devices shall be so arranged that the flame detecting element is correctly positioned.

5.8 If the temperature of the exterior of oven exceeds 71°C, it should be guarded by location guard rails, shields and insulation to prevent accidental contact with operating personnel.

6. EXPLOSION VENTS

6.1 For fuel fired ovens, in which there is no explosive solvent hazard and is equipped with all recommended fuel safety devices, an explosion venting ratio of 1 : 9 (one square metre of vent area to every 9 m³ of oven volume) should be provided.

6.2 Such vents, where possible, should be placed at the top of the oven or inside walls and so located that the employees are not exposed to injury.

6.3 Explosion relief vents for long ovens shall be reasonably distributed throughout the entire oven length.

6.4 The oven location should permit the shortest and most direct path for exhaust and relief ducts for discharging into atmosphere.

7. DUCTS

7.1 Ducts shall be constructed entirely of sheet steel or other non-combustible material, having adequate strength and rigidity to meet the conditions of service and installation requirements.

7.2 The surface temperature of all ducts, their backings, brackets and hangers should not exceed 71°C and they should be adequately lagged with mineral wool insulation.

7.3 All ducts shall be tight and leak proof throughout and shall have no openings other than those required for operation and maintenance.

7.4 Dampers in the ducts, which affect the volume of fresh air admitted and vapours or gases exhausted from the oven, shall be so designed that when closed they shall pass the volume required for safe ventilation.

7.5 All exposed hot fan casings and hot ducts within 2 metres of the building floor shall be protected to prevent any injury to personnel. The temperature shall not exceed 71°C.

7.6 Exhaust ducts shall not discharge near doors or windows or other air intakes in a manner that shall permit re-entry of exhaust products into the building.

7.7 Handholes for damper and shoot cleanout hole shall be equipped with tight fitting doors, with substantial latches and gaskets of sufficient durability to withstand normal usage.

8. DOORS

8.1 Doors shall be constructed in a similar manner as the oven panels and braced sufficiently and ruggedly against warpage due to heat.

8.2 Doors weighing more than 23 kg shall have a spring counter-balance or friction control, as a preliminary step.

8.3 For the vertically sliding doors, they shall slide up and down against steel guides and over rugged door frames which do not get warped.

8.4 Each door shall be equipped with an angle extension which when the door is closed shall fit into a sand seal above the door way. The sand seal and the door guides prevent escape of heat and gases from the door front.

8.5 Each door shall have a set of safety type quick acting roller cams which shall hold the door tightly against the oven frame and shall also permit the door to serve as an oven relief area.

8.6 The door operation may be pneumatic or motorized. In case it is hydraulic type, it should not use petroleum and other combustible hydraulic fluids. If at all it shall be used, the system shall be designed to minimize the possibility of fluid release, which may result in fire or explosion.

8.7 For pneumatic and hydraulic door operations, the cylinders shall be cushioned at both ends with speed control, solenoid valves and remote

push button control station. For the pneumatic system a lubricator, pressure regulator and filter unit shall be provided for each cylinder location.

9. CHARACTERISTICS OF FUELS

9.1 In conducting the performance tests, fuels having characteristics as shown below shall be used:

	<i>Heating Value*</i>	<i>Sp Gr at 15°C</i>
i) Fuel oil	10 000 kcal/kg	0.546 (for liquid with respect to water = 1)
ii) Liquified petroleum gas (LPG)	11 800 kcal/m ³	1.830 (for gas with respect to air = 1)
iii) LPG + air mixture	12 670 kcal/m ³ *	1.42 (with respect to air = 1)
iv) Natural gas (Baroda gas)	119 000 kcal/m ³ *	0.778 (with respect to air = 1)
v) Coke oven gas	4 200 kcal/m ³ *	0.45 (with respect to air = 1)
vi) Producer gas	1 300 kcal/m ³ *	0.90 (with respect to air = 1)

10. FUEL SAFETY CONTROL

10.1 Fuel safety control covers appliances, such as safety shut off valve, flame detection unit, time-delay relay (TDR) pressure switches — high and low, supervisory cocks, solenoid valves, etc. These devices shall be used to provide:

- Sufficient pre-ventilation,
- Sufficient ventilation during operation,
- Control of fuel combustion, and
- Oven temperature protection.

10.1.1 *Pre-ventilation or Purging*

- Pre-ventilation is essential for all ovens in which the fuel may accumulate during a shut down period or after an accidental flame failure;

*The heating value refers to 15°C, 760 mm mercury pressure and dry gas.

- b) For oven volumes less than 10 m^3 , the operation of purging may be omitted if the doors are opened for turning on the heat again;
- c) In all other ovens, of volume more than 10 m^3 , all doors, manholes and explosion vents shall be opened in such a way that the total vent area is 1 m^2 for every 4.5 m^3 of the oven;
- d) An approved time delay relay (TDR) shall be arranged in the safety control circuit and set so as to require the operation of exhaust and recirculating fans for sufficient time to provide 4 (four) oven volume changes of fresh air before the fuel is turned on or the conveyor is operated. An audible and visible alarm shall operate during the purge;
- e) Combustion blower shall be interlocked so that it may not be started, until the purge is completed; and
- f) Automatic recycling after accidental flame failure is not allowed.

10.1.2 Ventilation

- a) Exhaust ducts pockets shall be located in the area of greatest concentration of fumes and pockets of static gases; and
- b) All exhaust shall be equipped by mechanical means using power driven fans. Each oven shall be equipped with its own individual exhaust fan and not a common system, serving other ovens or equipment.

10.1.3 Control of Fuel Combustion — To control the fuel combustion the following protective devices may be provided:

- a) *Safety Shut-off Valve* — The primary safety shut-off valve used in the main fuel supply line shall be manually opened, automatically closed type. This valve shall be properly interlocked to shut down upon any abnormal operating conditions or failure of safety control circuit. A leak test facility shall be provided downstream of fuel supply shut-off valve.
- b) *Flame Detection Device* — It detects the presence or absence of flame and shall automatically shut off the fuel supply in the event of flame outage. The flame detection equipment shall have safe start check and 2 to 4 seconds flame failure response time. The flame detector shall be interlocked to shut down individual burners, separate zones, or the entire oven at the option of the manufacturer.
- c) *Pressure Switch* — A pressure activated device is arranged to effect a safety shutdown of the burner or burners from starting in

the event of a malfunction with respect to the pressure of the fuel or combustion air. Both automatic and manual reset type pressure switches are acceptable. They shall be interlocked with a safety-shut off valve to stop the fuel flow when abnormal fuel pressure or combustion air pressure occur. The abnormal pressures may be higher or lower than specified for safe and correct operation of burner zones or entire oven.

- d) *Safety Blow Device* — It is a device provided near the outlet of each gas mixing machine, where the nominal size of piping is larger than 65 mm to protect the machine in the event of air explosion through an automatic fire check, covering a flame arrester, a blow out disk, provision of automatic shutting of the supply of air gas mixture.
- e) *Ignition System* — Ovens when operating below 760°C shall have burner ignition by spark ignited interrupted pilots, torch or by direct spark ignited self piloted burners. The burners shall produce stable flame during the trial-for-ignition period. When pilots, or main burners are spark-ignited, the spark shall be shut-off at the end of the trial-for-ignition period.

10.1.4 Excess Temperature Controller — It shall be provided and suitably interlocked with the safety control circuit so that all the main burners controlled by the circuit shall be shut off in the event of excess temperatures. It shall not automatically re-open the fuel valve. This control shall be in addition to any normal temperature control devices used.

10.2 To ensure further the closure of all individual main burners cocks, before the main burner shut off valve may be opened, the fuel safety control system shall guarantee the following interlock operations also, namely:

- a) combustion air pressure is normal,
- b) atomizing medium pressure is normal,
- c) normal gas pressure in the pilot is normal,
- d) ventilation fan is operating,
- e) pre-ventilation purge is completed, and
- f) the combustion safeguard of the pilot opens its safety solenoid/ shut-off valve.

10.3 Typical arrangement for fuel safety control for gas fired and oil fired heating systems is shown in Fig. 3 and Fig. 4 respectively.

11. FUEL OIL AND FUEL GAS BURNERS

11.1 The main burner system shall operate on high-low flame. For oil burners one of the following alternatives shall be adopted:

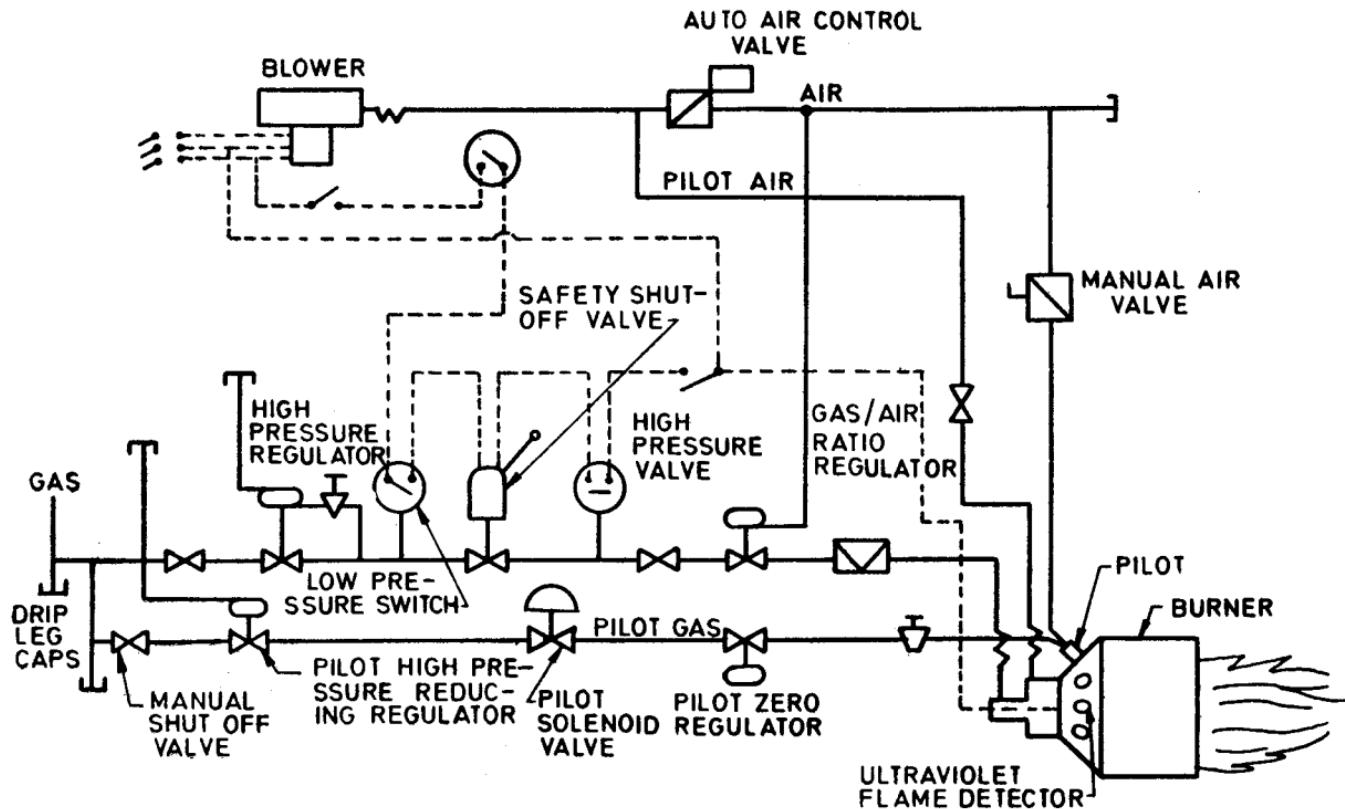


FIG. 3 SAFETY CONTROL FOR GAS FIRED BURNER

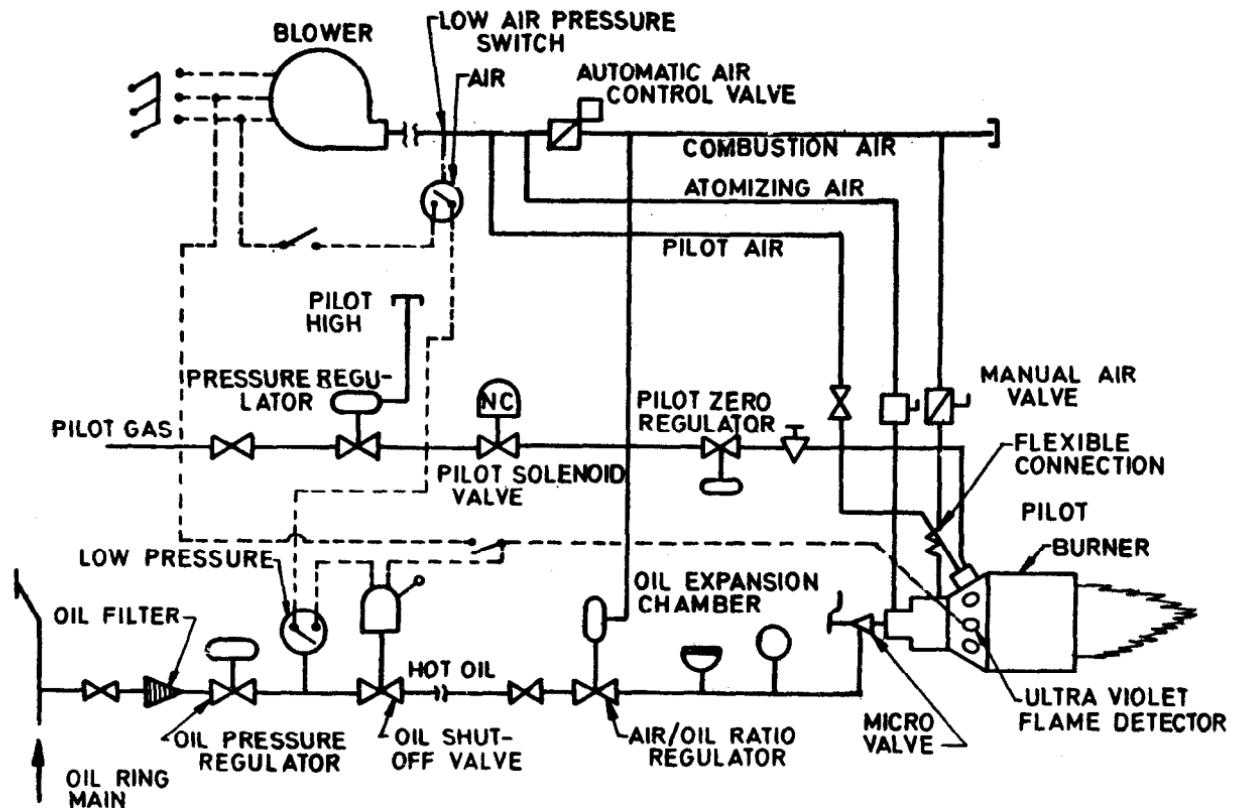


FIG. 4 SAFETY CONTROL FOR OIL FIRED BURNER

- a) *Self Proportioning Low Air Pressure Oil Burner with Single Lever Air Oil Control Lever* — The control lever may be operated manually or by a reversible modulating servo-motor or a pneumatic cylinder. The single lever operation shall permit automatic proportioning of air-oil ratio, based on the feed back received from the temperature control instrument.
- b) *Low Air Pressure Oil Burner* — It may have external ratio regulator for proportioning air/oil ratio. The regulator may be used for individuals burners, or zones or entire oven and cross-connected to combustion air line downstream of air control valve. The change in pressure across the valve will be the pressure impulse on the diaphragm of the regulator. The oil flow will be thereby regulated automatically in proportion with air flow. The oil pressure before the ratio regulator shall be $1.5 - 2.0 \text{ kg/cm}^2$. The air control valve may be manually or serv~~o~~ motor operated by the feed back received from the temperature control instrument. These burners shall have separate inlet ports for atomizing and combustion air.

11.2 The combustion and atomizing air pressure shall be specified by the burner manufacturer but the atomizing air pressure shall be not less than 620 mm WG for light distillate oils and 970 mm WG for heavy oil. Excess air burners with high flame stability is desirable for low temperature ovens. These burners shall also be capable of firing on ratio.

11.3 Gas burners shall be essentially nozzle mix type. Air gas regulator shall be used for proportioning gas with regard to air by cross connecting the regulator to the main air line down stream of the air control valve. Burners shall have high degree of stability under excess air conditions.

12. BURNER CHARACTERISTICS

12.1 Burner appliance for use with any fuel shall be tested in its own specific equipment and with reference to the rated input and the turn-down ratio.

12.2 Adequate means shall be provided for ease in observation of the conditions at the burner and its ignition zone.

12.3 Each burner shall be equipped with an approved instantaneous flame sensing combustion safeguard arranged through a suitable approved safety shut off valve to shut off fuel to the burner in the event of flame failure.

12.4 Flames on their own shall be stable even when variations in burning characteristics of the fuel, normal variations in fuel handling

and the burner intervals introduce an uncertainty to the lower operating limit.

12.5 The flame sensing element of the combustion safeguard shall be so located as to prove the pilot flame and monitor the intersection of the main and the pilot burner flame paths, so that prompt reliable ignition by the pilot is assured before the main fuel valves are opened.

12.6 The main burner shall be immediately ignited by the pilot even when it is reduced to a minimum flame, that shall barely hold the flame sensing relay of the combustion safeguard in the energized (flame) position.

12.7 There shall be no automatic recycling after accidental flame failure. All fuel shall be shut off that is, safety shut-off valves tripped/closed. The attention of an operator is necessary before the next pilot-flame establishing period of trial-for ignition can start.

13. PILOT

13.1 The pilot shall not deposit appreciable carbon during its operation.

13.2 It shall not flash back and shall remain stable even during substantial fluctuations in draft or back pressure.

13.3 The gas pressure on the inlet side of the pilot burner shall be supervised by an approved gas pressure switch, in conjunction with a low combustion air pressure switch, a checking pressure switch (which supervises the individual burner cocks) and a shunting low gas pressure switch installed down-stream from the main safety shut-off valve.

14. PRESSURE SWITCH

14.1 These pressure activated devices shall withstand the fuel being handled, the cyclic operations required for the fuel safety control and shall be extremely reliable in its function.

14.2 The quality of the diaphragm shall be such as to sustain a maximum temperature rise of 65°C allowed near the burner system.

14.3 In the case of liquid fuels, low oil temperature limit switch shall be provided so as to guarantee the correct viscosity of the oil through the burner nozzle, for good atomization.

15. TEMPERATURE CONTROLLERS

15.1 These devices shall measure and indicate the temperature accurately and automatically, with the help of a thermocouple or mercury-in-steel thermometer and control the heat input of the burner by operating the reversible servo-motor or the pneumatic cylinder. The exact location of

the thermocouple shall be carefully chosen so as to represent the average of the temperature distribution pattern in the entire oven. The instrument however shall control within $\pm 5^{\circ}\text{C}$ of the desired temperature at the chosen location of the thermocouple.

15.2 The excess temperature controller shall cut off the fuel supply when the temperature exceeds a safe limit at a location, from where the thermocouple or thermometer probe shall monitor the temperature which directly affects safety in most cases.

16. THERMAL EFFICIENCY

16.1 The design of an oven is invariably tailor made. As such the thermal efficiency of an oven shall depend on a number of factors. To calculate thermal efficiency the following data shall be required:

a) Maximum and minimum rated heat input	kcal/h
b) Baking and cooling cycle time	h
c) Maximum variation in baking temperature	$^{\circ}\text{C}$
d) Maximum external surface area of the oven casing	m^2
e) Maximum temperature of the casing surface	$^{\circ}\text{C}$
f) Fresh air admitted/hour Temperature of fresh air	m^3/h $^{\circ}\text{C}$
g) Exhaust gas volume/hour Exhaust gas temperature	m^3/h $^{\circ}\text{C}$
h) Recirculation fan capacity Temperature of the gas handled Static pressure of the fan	m^3/h $^{\circ}\text{C}$ mm of water gauge
j) Internal volume of the oven No. of volume changes/hour (Recirculation fan capacity Internal oven volume)	m^3 No./h

17. DESIGN

17.1 The oven shall be designed keeping in view the various parameters involved.

17.2 The following information shall be required:

- Type of oven (see Fig. 1);
- Type of heating arrangement and combustion details (see Fig. 2);

- c) Rated heat input (kcal/h);
- d) Turn-down ratio;
- e) Fuel, its characteristics, heating value and sp gr;
- f) No. of burners;
- g) Manual lighting, fixed continuous pilot, high-low main burner flame;
- h) Vent area locations, No. of latches and total area per unit volume of the oven;
- j) Details of fuel safety control, location and type of operation for emergency;
- k) Oven panel construction details, its thermal conductivity, kcal;
- m) Size of the exhaust duct;
- n) Size and location of cleanout doors; and
- p) Fire protection for oven.

17.3 To approve the design, construction and performance of an oven, the following data shall be required.

a) Mould Core Data

- i) No. of cores/moulds, per hour;
- ii) Types of cores/moulds with respect to their surface area, maximum thickness and quantity of each type;
- iii) Maximum percent of moisture, in cores, by weight, in kg/h;
- iv) Litres of core oils/kg of core sand, raw linseed oil Pertel oil, etc, which oxidize and polymerize at the baking temperature;
- v) kg of steel/hour;
- vi) kg of dry sand/hour;
- vii) Gas in ml per g of green core/mould; and
- viii) Gas in ml per g of baked/mould.

b) Drying Characteristics

- i) Fresh air temperature and relative humidity;
- ii) Baking temperature;
- iii) Baking time; and
- iv) Cooling time required after baking.